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09/691,915

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : A01N 43/80 // (A01N 43/80, 43:707, 43:70) — A1

(11) International Publication Number: **WO 95/15691**

(43) International Publication Date: 15 June 1995 (15.06.95)

(21) International Application Number: PCT/EP94/04052

(22) International Filing Date: 6 December 1994 (06.12.94)

(30) Priority Data:
9325284.9 10 December 1993 (10.12.93) GB

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(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ).

Published

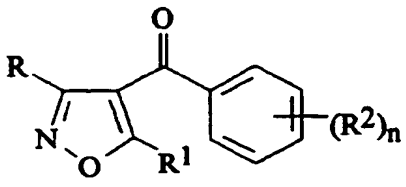
With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: HERBICIDAL COMPOSITIONS

(57) Abstract

The invention relates to compositions comprising a 4-benzoylisoxazole derivative of formula (I), wherein R, R^1, R^2 and n are as defined in the description, and a triazine herbicide, and their use as herbicides.



(I)

Q^3 X'

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Herbicidal Compositions

The present invention relates to new herbicidal compositions comprising a mixture of 1,3,5-triazine or 1,2,4-triazinone herbicides and 4-benzoylisoxazole derivatives, and to their use in agriculture.

The above compounds are already known in the art as herbicides. 1,3,5-Triazine and 1,2,4-triazinone herbicides (hereinafter referred to as the triazine herbicides) include ametryn (N^2-ethyl-N^4-isopropyl-6-methylthio-1,3,5-triazine-2,4-diamine), atrazine (6-chloro-N^2-ethyl-N^4-isopropyl-1,3,5-triazine-2,4-diamine), aziprotryne (4-azido-N-isopropyl-6-methylthio-1,3,5-triazin-2-ylamine), cyanazine [2-(4-chloro-6-(ethylamino)-1,3,5-triazin-2-ylamino)-2-methylpropionitrile], methoprotryne [N^2-isopropyl-N^4-(3-methoxypropyl)-6-methylthio-1,3,5-triazine-2,4-diamine], metribuzin (4-amino-6-*tert*-butyl-3-methylthio-1,2,4-triazin-5(4H)-one), prometryn (N^2,N^4-di-isopropyl-6-methylthio-1,3,5-triazine-2,4-diamine), prometon (N^2,N^4-di-isopropyl-6-methoxy-1,3,5-triazine-2,4-diamine), propazine (6-chloro-N^2,N^4-di-isopropyl-1,3,5-triazine-2,4-diamine), simetryn (N^2,N^4-diethyl-6-methylthio-1,3,5-triazine-2,4-diamine), simazine (6-chloro-N^2,N^4-diethyl-1,3,5-triazine-2,4-diamine), terbuthylazine (N^2-*tert*-butyl-6-chloro-N^4-ethyl-1,3,5-triazine-2,4-diamine), terbutryn (N^2-*tert*-butyl-N^4-ethyl-6-methylthio-1,3,5-triazine-2,4-diamine) and trietazine (6-chloro-N^2,N^2,N^4-triethyl-1,3,5-triazine-2,4-diamine), and are disclosed for example in "The Pesticide Manual", 9th edition (British Crop Protection Council) as selective herbicides. Herbicidal 4-benzoylisozaxoles of formula I below are disclosed in European Patent Publication Numbers 0418175, 0487357, 0527036 and 0560482.

As a result of research and experimentation it has been found that the use of a triazine herbicide, in combination with certain 4-benzoylisozaxole derivatives, extends the spectrum of herbicidal activity without loss of crop selectivity. Therefore the said combinations represents an important technological advance. The term "combination" as used in this specification refers to the

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term "combination" as used in this specification refers to the "combination" of a 4-benzoylisoxazole herbicide and a triazine herbicide.

Surprisingly, in addition to this, it has been found that the combined herbicidal activity of certain 4-benzoylisoxazoles with triazine herbicide for the control of certain weed species, including Brachiara plantaginea, Echinochloa crus-galli, Bidens pilosa, Cassia occidentalis, Ipomoea aristolochiaefolia, Euphorbia heterophylla, Setaria spp, Abutilon theophrasti, Amaranthus retroflexus, Ipomoea purpurea, Sida spinosa, Xanthium strumarium and Digitaria sanguinalis is greater than expected, without an unacceptable increase in crop phytotoxicity, applied pre- or post- emergence (e.g. as a pre- or post- emergence aqueous spray), i.e. the herbicidal activity of the 4-benzoylisoxazole with a triazine herbicide showed an unexpected degree of synergism, as defined by Limpel, L.E., P.H. Schuldt and D. Lamont, 1962, 1. Proc. NEWCC 16, 48-53, using the formula:-

$$E = X + Y - \frac{X.Y}{100}$$

where

E = the expected percent inhibition of growth by a mixture of two herbicides A and B at defined doses.

X = the percent inhibition of growth by herbicide A at a defined dose.

Y = the percent inhibition of growth by herbicide B at a defined dose.

When the observed percentage of inhibition by the mixture is greater than the expected value E using the formula above the combination is synergistic.

The remarkable synergism on of certain combinations on Brachiara plantaginea, Echinochloa crus-galli, Bidens pilosa, Cassia occidentalis, Ipomoea aristolochiaefolia, Euphorbia heterophylla, Setaria spp, Abutilon theophrasti, Amaranthus retroflexus, Ipomoea purpurea, Sida spinosa, Xanthium strumarium and Digitaria sanguinalis gives improved reliability in controlling these competitive weeds of many crop species, leading to a considerable

BNSDOCID: <WO___9515691A1_I_>

reduction in the amount of active ingredient required for weed control.

A high level of control of these weeds is desirable to prevent:-

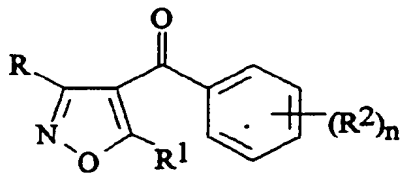
1) yield loss, through competition and/or difficulties with harvest,

2) crop contamination leading to storage and cleaning difficulties, and

3) unacceptable weed seed return to the soil.

Accordingly the present invention provides a method for controlling the growth of weeds (i.e. undesired vegetation) at a locus which comprises applying to the locus:

(a) a 4-benzoylisoxazole derivative of formula I:



(I)

wherein

R is hydrogen or $-CO_2R^3$;

R^1 is cyclopropyl;

R^2 is selected from halogen (preferably chlorine or bromine), $-S(O)_pMe$ and C_{1-6} alkyl or haloalkyl (preferably trifluoromethyl),

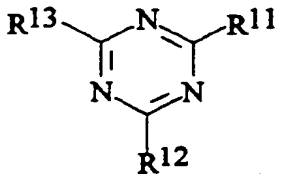
n is two or three; p is zero, one or two; and

R^3 is C_{1-4} alkyl; and

(b) a triazine herbicide.

For this purpose, the 4-benzoylisoxazole and triazine herbicide are normally used in the form of herbicidal compositions (i.e. in association with a herbicidally acceptable diluent or carrier and/or surface active agent), for example as hereinafter described.

Preferably the triazine herbicide is a compound of formula II:



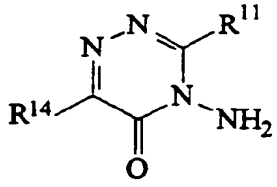
(II)

wherein R^{11} represents chlorine or straight- or branched chain

BNSDOCID: <WO___9515691A1_I_>

represents azido, monoalkylamino, dialkylamino or cycloalkylamino, in which the alkyl or cycloalkyl moieties may be optionally substituted by one or more substituents selected from cyano and alkoxy; and R^{13} represents straight-or branched- chain N-alkylamino having from one to six carbon atoms;

or of formula III:



(III)

wherein R^{14} represents straight- or branched chain alkyl having from one to six carbon atoms.

More preferably R^{11} represents chlorine or methylthio and R^{13} represents straight- or branched- chain N-alkylamino having from one to four carbon atoms.

Compositions containing compounds of formula II above wherein R^{12} represents azido, straight- or branched- chain N-alkylamino having from one to four carbon atoms (wherein the alkyl moiety is optionally substituted by cyano or methoxy) are preferred.

Further preferred compounds of formula II above are those in which R^{13} represents N-(t-butyl)amino, R^{12} represents N-ethylamino and R^{11} represents chlorine or methylthio, which are known respectively as terbuthylazine and terbutryn.

Preferred compounds of formula II above are those in which R^{11} represents chlorine, R^{13} represents N-ethylamino and R^{12} represents N-ethylamino, N-(2-methylpropanenitrile)amino or N-isopropylamino, known respectively as simazine, cyanazine and atrazine, cyanazine and atrazine being most preferred.

A preferred compound of formula III above is the compound in which R^{11} represents methylthio, R^{14} represents tert-butyl, which is known as metribuzin.

In formula I above, preferably one of the groups R^2 is $-S(O)_pMe$.

BNSDOCID: <WO___9515691A1_I_>

In formula I above, compounds in which n is three and the groups $(R^2)_n$ occupy the 2,3 and 4-positions of the benzoyl ring; or in which n is two and the groups $(R^2)_n$ occupy the 2 and 4- positions of the benzoyl ring are preferred.

In formula I above, preferably $(R^2)_n$ is 2-SO_2Me-4-CF_3, 2-CF_3-4-SO_2Me, 2-Cl-4-SO_2Me, 2-SO_2Me-4-Br, 2-SO_2Me-4-Cl or 2-SMe-3,4-dichloro.

Particularly preferred compounds of formula I include the following:

A 5-cyclopropyl-4-(2-methylsulphonyl-4-trifluoromethyl)benzoylisoxazole;

B 5-cyclopropyl-4-(4-methylsulphonyl-2-trifluoromethyl)benzoylisoxazole;

C 4-(2-chloro-4-methylsulphonyl)benzoyl-5-cyclopropylisoxazole;

D 4-(4-chloro-2-methylsulphonyl)benzoyl-5-cyclopropylisoxazole;

E 4-(4-bromo-2-methylsulphonyl)benzoyl-5-cyclopropylisoxazole;

F ethyl 3-[5-cyclopropyl-4-(3,4-dichloro-2-methylsulphenyl)benzoylisoxazole]carboxylate; and

G 5-cyclopropyl-4-(3,4-dichloro-2-methylsulphonyl)benzoylisoxazole.

The letters A to G are assigned to these compounds for reference and identification hereafter.

Compounds A and F are particularly preferred.

The amounts of the triazine herbicide and 4-benzoylisoxazole applied vary depending on the the weeds present and their population, the compositions used, the timing of the application, the climatic and edaphic conditions, and (when used to control the growth of weeds in crop growing areas) the crop to be treated. In general, taking these factors into account, application rates from 5g to 500g of 4-benzoylisoxazole and from 250g to 5000g of the triazine herbicide per hectare give good results. However, it will be understood that higher or lower application rates may be used, depending upon the problem of weed control encountered.

BNSDOCID: <WO___9515691A1_I_>

For the selective control of weeds at a locus of weed infestation which is an area used, or to be used, for growing of crops application rates from 5g to 500g of 4-benzoylisoxazole and from 250g to 5000 g of the triazine herbicide per hectare are particularly suitable, preferably from 25 to 150g of 4-benzoylisoxazole and from 500 g to 1500 g of the triazine herbicide per hectare. When applied to a crop-growing area, the rate of application should be sufficient to control the growth of weeds without causing substantial permanent damage to the crop.

According to a further feature of the present invention there is provided a method of controlling the growth of weeds at a locus which comprises the the combined use of

(a) 4-benzoylisozaxole of formula I as defined above; and

(b) a triazine herbicide;

by pre- or post- emergence application.

The combined use described above may be used to control a very wide spectrum of annual broad-leafed weeds and grass weeds in crops, e.g. maize, plantatation crops such as sugar cane, without significant permanent damage to the crop. The combined use described above offers both foliar and residual activity and consequently can be employed over a long period of crop development, i.e. from pre-weed pre-crop emergence to post-weed post-crop emergence.

In the method according to this feature of the present invention the combined use of (a) and (b) to control grass weeds in maize is preferred.

Where the triazine herbicide is ametryn the combined use of (a) and (b) to control grass weeds in sugar cane is also preferred.

Preferably the herbicides are applied pre-emergence of the weeds. Where the compound of formula (I) is Compound F above, post-emergence application is preferred.

In the method described above, the combined use of (a) and (b) in proportions of 2:1 to 1:1000 wt/wt of (a) : (b) is preferred, proportions of 1:3.3 to 1:60 wt/wt being particularly preferred.

By the term 'pre-emergence application' is meant application to the soil in which the weed seeds or seedlings are present before

BNSDOCID: <WO__9515691A1_I_>

emergence of the crop. By the term 'post-emergence application' is meant application to the aerial or exposed portions of the weeds which have emerged above the surface of the soil. By the term 'foliar activity' is meant herbicidal activity produced by application to the aerial or exposed portions of the weeds which have emerged above the surface of the soil. By the term 'residual activity' is meant herbicidal activity produced by application to the soil in which weed seeds or seedlings are present before emergence of the weeds above the surface of the soil, whereby seedlings present at the time of application or which germinate subsequent to application from seeds present in the soil, are controlled.

In accordance with the usual practice, a tank mix may be prepared prior to use by combining separate formulations of the individual herbicidal components.

The following non-limiting experiments illustrate the present invention.

GENERAL EXPERIMENTAL PROCEDURE

Experiment A

The experiments were carried out pre-emergence of the weed species at a research farm in Brazil. Compound A (formulated as a wettable powder) and atrazine were weighed out and dissolved in water to give a solution containing the appropriate concentrations and ratios of active ingredients.

The solution was mixed for one hour and applied at a spray volume of 231 litres/hectare to a 3 metre by 5 metre test plot comprising the weed species which were sown 2 days earlier. 3 replicates were performed. A control plot was sprayed with a solution not containing test compound. Visual assessment of phytotoxicity was made after 36 days from sowing each weed species based on a comparison with the control plot.

The tables below show the observed percentage control of the weed species by each combination, with the figure in brackets representing the predicted value using the Limpel formula.

BNSDOCID: <WO___9515691A1_I_>

EXAMPLE A1

Trials showing the nature of the synergistic biological effect of the combination on Brachiara plantaginea

	Compound A			
	g (a.i.)/ha	0	75	100
Atrazine	0	-	77	87
	1250	10	95(79)	95(88)

EXAMPLE A2

Trial demonstrating the nature of the synergistic biological effect of the combination on Echinochloa crus-galli

	Compound A			
	g (a.i.)/ha	0	75	100
Atrazine	0	-	77	88
	1250	27	95(83)	97(91)

EXAMPLE A3

Trial demonstrating the nature of the synergistic biological effect of the combination on Bidens pilosa

	Compound A			
	g (a.i.)/ha	0	75	100
Atrazine	0	-	35	67
	1250	70	87(81)	95(90)

BNSDOCID: <WO___9515691A1_I_>

EXAMPLE A4

Trial demonstrating the nature of the synergistic biological effect of the combination on Cassia occidentalis

	Compound A			
	g (a.i.)/ha	0	75	100
Atrazine	0	-	5	37
	1250	25	77(29)	85(53)

EXAMPLE A5

Trial demonstrating the nature of the synergistic biological effect of the combination on Ipomoea aristolochiaefolia

	Compound A			
	g (a.i.)/ha	0	75	100
Atrazine	0	-	5	33
	1250	52	88(54)	96(68)

EXAMPLE A6

Trial demonstrating the nature of the synergistic biological effect of the combination on Euphorbia heterophylla

	Compound A			
	g (a.i.)/ha	0	75	100
Atrazine	0	-	5	27
	1250	23	82(27)	87(44)

Experiment B

The experiments were carried out pre-emergence of the weed species at a research farm in Washington state, USA. Compound B (formulated as a wettable powder) and atrazine (formulated as a suspension concentrate) were weighed out and dissolved in water to give a solution containing the appropriate concentrations and ratios of active ingredients.

The solution was mixed for one hour and applied at a spray

BNSDOCID: <WO___9515691A1_I_>

volume of 231 litres/hectare to a 3 metre by 5 metre test plot comprising the weed species which were sown 2 days earlier. 3 replicates were performed. A control plot was sprayed with a solution not containing test compound. Visual assessment of phytotoxicity was made after 42 days from sowing each weed species based on a comparison with the control plot.

The tables below show the observed percentage control of the weed species by each combination, with the figure in brackets representing the predicted value using the Limpel formula.

EXAMPLE B1

Trial demonstrating the nature of the synergistic biological effect of the combination on Setaria faberi

	Compound B		
	g (a.i.)/ha	0	50
Atrazine	0	-	68
	1000	87	100(96)

With reference to the formula given at the beginning of the description, the results above clearly demonstrate the excellent and unexpected degree of synergism obtained with the combination of the invention.

It will be understood that the results presented above were all obtained in field trials. Such trials generally represent a more rigorous test of herbicidal properties than tests in the greenhouse, where test plants are protected from the variable conditions to which they are inevitably subject in the open field. Because of the variability of conditions in field tests, it is generally more difficult to secure a clear showing of synergism than in greenhouse testing. Nevertheless, herbicidal mixtures which demonstrate synergism in greenhouse testing must, if they are to be of commercial utility, be capable of demonstrating synergism under field conditions, i.e.under the conditions which will prevail when they are used by a farmer. The results obtained in the foregoing Examples therefore represent

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a particularly clear demonstration of synergism under practical conditions.

Experiment C

The following experiments were carried out using Compound A in mixtures with various triazine herbicides (atrazine and cyanazine). Seed of the various species of broad-leaf or grass weeds were sown in unsterilised clay loam soil in 7 centimetre by 7 centimetre plastic plant pots. The pots were watered and allowed to drain. The soil surface was then sprayed with ranges of concentrations of either the individual herbicide or mixtures of two herbicides (compound A and atrazine as technical material; cyanazine as the commercially available formulation "Fortrol", trade mark, which is a suspension concentrate) in various proportions, dissolved in a 50:50 by volume solution of acetone and water, using a track sprayer set to deliver the equivalent of 290 l/ha. The herbicides were used as unformulated technical materials.

Treated pots were placed at random in four replicate blocks per treatment for each plant species. The pots were held, in a glasshouse, standing on moist capillary matting, under lights and with overhead watering twice daily.

Two weeks after treatment the percent reduction in plant growth, compared to an untreated control, was assessed.

Mean percent reduction in plant growth was calculated for each treatment. Dose/mean response was plotted on Log concentration/Probability graph paper, and lines fitted by eye. For herbicide mixtures a dose/response line for the first herbicide was drawn for each dose rate of the second herbicide and a dose/response line for the second herbicide was drawn for each dose rate of the first herbicide. The doses representing a 90% reduction in plant growth (LD90 values) were read from these lines and plotted on graphs whose axes were dose rates of the two herbicides. The line joining these points is an Isobole i.e. a line joining points (mixtures) of equal activity, as described by P.M.L. Tammes, Neth. J. Plant Path. 70 (1964) : 73-80. A line was also drawn joining the LD90 values of the individual components of the mixture. This line represents the theoretical isobole if the effect of

BNSDOCID: <WO___9515691A1_I_>

the two components is additive i.e. there is no interaction between them. Isoboles falling below this line indicate synergy between the components while lines lying above it indicate antagonism.

In the tables that follow 'dose' represents the dose rate in grammes per hectare of the active ingredient used; and the figures for the weed control are percentages reduction in growth when compared with the untreated controls.

Example C1

Pre-emergence treatment of Abutilon theophrasti with various mixtures of Compound A and atrazine

	Atrazine							
	Dose g/ha	0	31.25	62.5	125	250	500	1000
Cpd A	0	-	25	51.25	75	87.5	93.75	100
	1	40	45	95	100	87.5	100	100
	2	46.25	62.5	77.5	75	97.5	100	100
	4	20	66.25	75	90	87.5	100	100
	8	75	68.75	62.5	81.25	93.75	100	100
	16	91.25	97.5	100	100	100	93.75	100
	32	88.75	100	97.5	100	80	100	100
	64	98.75	100	100	93.75	98.75	100	100
	128	100	100	100	93.75	100	100	91.25
	256	97.5	100	100	100	100	100	97.5

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Example C2

Pre-emergence treatment of Amaranthus retroflexus with various mixtures of Compound A and atrazine

	Atrazine							
	Dose g/ha	0	31.25	62.5	125	250	500	1000
	0	-	67.5	32.5	82.5	100	75	87.5
	1	42.5	57.5	95	93.75	100	97.5	100
	2	22.5	43.75	95	93.75	93.75	100	100
	4	60	72.5	95	98.75	100	87.5	95
Cpd A	8	75	93.75	100	100	100	100	100
	16	75	100	97.5	100	100	96.25	100
	32	100	95	100	100	100	95	97.5
	64	100	100	98.75	100	100	100	100
	128	100	100	95	100	100	100	100
	256	98.75	100	100	100	100	100	100

Example C3

Pre-emergence treatment of Echinochloa crus-galli with various mixtures of Compound A and atrazine

	Atrazine								
	Dose g/ha	0	31.25	62.5	125	250	500	1000	2000
	0	-	5	15	50	61.25	86.25	88.75	97.5
	1	0	10	41.25	30	48.75	83.75	90	95
	2	5	2.5	42.5	40	62.5	86.25	91.25	96.25
	4	0	15	40	78.75	86.25	92.25	98.75	97.5
	8	10	52.5	55	84.75	92.5	97.5	97.5	100
Cpd A	16	51.25	73.75	62.5	88.75	89.75	97.5	96.67	97.5
	32	86.25	92.5	92.5	96.25	96.25	96.25	96.25	97.5
	64	95	98.75	95	96	97.5	96.25	97.25	100
	128	95	95	95	95	95	96.25	95	95
	256	95	95	95	95	97.5	95	97.5	95

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Example C4

Pre-emergence treatment of Ipomoea purpurea with various mixtures of Compound A and atrazine

	Atrazine								
	Dose g/ha	0	31.25	62.5	125	250	500	1000	2000
	0	-	65	67.5	86.25	92.5	93.75	97.5	100
	1	28.75	26.25	85	98.5	96.25	95	82.5	97.5
	2	47.5	41.25	68.75	95	100	98.75	100	100
	4	37.5	80	92.5	88.75	98.75	92.5	97.5	100
	8	47.5	30	86.25	97.5	100	97.5	100	100
Cpd A	16	37.5	71.25	83.75	91.25	97.5	95	85	95
	32	53.75	90	95	95	97.5	100	100	92.5
	64	67.5	78.75	96.67	97.5	97.5	99.75	93.75	100
	128	70	95	100	100	100	100	95	98.75
	256	91.25	98.75	96.25	100	97.5	97.5	100	100

Example C5

Pre-emergence treatment of Setaria viridis with various mixtures of Compound A and atrazine

	Atrazine								
	Dose g/ha	0	31.25	62.5	125	250	500	1000	2000
	0	-	6.25	10	17.5	56.25	56.25	62.5	77.5
	1	7.5	0	10	0	62.5	80	72.5	97.5
	2	5	12.5	18.75	0	12.5	62.5	85	73.75
	4	25	25	15	0	28.75	30	68.75	95
	8	60	25	47.5	43.75	45	83.75	91.25	100
Cpd A	16	68.75	36.25	61.25	60	73.75	95	100	97.5
	32	85	77.5	81.25	76.25	92.5	96.25	96.25	96.25
	64	97.5	65	80	100	73.75	93.75	100	99.75
	128	86.25	97.5	85	98.75	100	100	100	100
	256	98.75	100	95	98.75	98.75	98.75	98.75	100

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Example C6

Pre-emergence treatment of Echinochloa crus-galli with various mixtures of Compound A and cyanazine

		Cyanazine							
	Dose g/ha	0	31.25	62.5	125	250	500	1000	2000
	0	-	12.5	7.5	0	62.5	63.75	90	94.75
	1	13.75	2.5	10	7.5	52.5	92.5	98.5	97.5
	2	20	13.75	2.5	17.5	48.75	92.25	97.5	95
	4	22.5	5	25	55	63.75	97.25	96.25	100
	8	37.5	53.75	52.5	63.75	86.25	99.75	98.75	98.5
Cpd A	16	73.75	70	77.5	88.75	90	99.75	100	99.75
	32	91.25	91.25	91.25	98.75	94.75	99.75	99.75	100
	64	98.5	100	100	96	100	99.5	99.75	99.5
	128	100	99.75	98	98.25	100	99.75	99.5	98.25
	256	99.25	98.25	99.75	98.25	99.5	99	98.25	99.25

Example C7

Pre-emergence treatment of Amaranthus retroflexus with various mixtures of Compound A and cyanazine

		Cyanazine						
	Dose g/ha	0	31.25	62.5	125	250	500	1000
	0	-	42.5	71.25	45	80	96.25	93.75
	1	57.5	50	67.5	83.75	95	91.25	98.75
	2	62.5	87.5	50	89.75	95	93.75	98.75
	4	55	90	87.5	97.5	97.5	95	99.75
	8	87.5	82.5	96.25	96.25	100	97.5	98.75
A	16	91.25	90	99.5	97.5	99.75	100	98.75
	32	98.75	100	100	100	98.75	100	100
	64	97.5	100	100	100	98.75	99.75	98.75
	128	97.5	97.5	100	100	100	100	100
	256	100	100	100	98.75	100	100	98.75
	512	100	98.75	100	100	98.75	100	100

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Example C8

Pre-emergence treatment of Ipomoea purpurea with various mixtures of Compound A and cyanazine

		Cyanazine						
	Dose g/ha	0	31.25	62.5	125	250	500	1000
	0	-	0	0	3.75	78.75	98.75	100
	1	6.25	2.5	2.5	37.5	82.5	80	100
	2	6.25	17.5	7.5	47.5	47.5	98.75	100
	4	2.5	45	5	58.75	65	100	100
	8	6.25	36.25	28.75	52.5	72.5	98.5	99.75
Cpd.A	16	26.25	58.75	57.5	66.25	85	93.75	100
	32	25	52.5	70	96.25	87.5	97.5	96.25
	64	75	75	88.75	95	100	96.25	100
	128	77.5	78.75	91.25	96.25	100	98.75	100
	256	68.75	90	91.25	97.5	97.25	98.75	100
	512	96.25	92.5	92.5	97.5	100	100	100

Brief Description of Drawings

Figure I is an LD90 isobole plot calculated from observed values (-•-) and a corresponding plot of expected additive values (dashed line) for a range of mixtures of Compound A with atrazine against the weed species Abutilon theophrasti, produced from the results shown in Table C1;

Figure II is an LD90 isobole plot calculated from observed values (-•-) and a corresponding plot of expected additive values (dashed line) for a range of mixtures of Compound A with atrazine against the weed species Amaranthus retroflexus, produced from the results shown in Table C2;

Figure III is an LD90 isobole plot calculated from observed values (-•-) and a corresponding plot of expected additive values (dashed line) for a range of mixtures of Compound A with atrazine against the weed species Echinochloa crus-galli, produced from the results shown in Table C3;

Figure IV is an LD90 isobole plot calculated from observed values (-•-) and a corresponding plot of expected additive values (dashed line) for a range of mixtures of Compound A with atrazine against the weed species Ipomoea purpurea, produced from the

results shown in Table C4;

Figure V is an LD90 isobole plot calculated from observed values (-•-) and a corresponding plot of expected additive values (dashed line) for a range of mixtures of Compound A with atrazine against the weed species Setaria viridis, produced from the results shown in Table C5;

Figure VI is an LD90 isobole plot calculated from observed values (-•-) and a corresponding plot of expected additive values (dashed line) for a range of mixtures of Compound A with cyanazine against the weed species Echinochloa crus-galli, produced from the results shown in Table C6;

Figure VII is an LD90 isobole plot calculated from observed values (-•-) and a corresponding plot of expected additive values (dashed line) for a range of mixtures of Compound A with cyanazine against the weed species Amaranthus retroflexus, produced from the results shown in Table C7;

Figure VIII is an LD90 isobole plot calculated from observed values (-•-) and a corresponding plot of expected additive values (dashed line) for a range of mixtures of Compound A with cyanazine against the weed species Ipomoea purpurea, produced from the results shown in Table C8.

The isoboles produced from the data in Examples D1 to D8, shown hereinafter in Figures I to VIII respectively, were clearly type III curves (Tammes op. cit., Page 75, Fig 2) characteristic of synergism.

Experiment D

The following experiments were conducted to demonstrate the post-emergence properties of mixtures comprising compound F (as a 50%wettable powder) and metribuzin (as a 70% water-dispersible granules, using the commercially available formulation "Sencor", trade mark). The two herbicides were made up in a solution containing 0.1% Agral (trade mark) and applied post-emergence both alone and in combination at a range of concentrations to the grass and broad-leaved weed species listed below. The spray jet (Model SS8003E) and pressure used (46psi) gave a spray volume equivalent to 290litres/ha. All plants were grown in non-sterile

BNSDOCID: <WO___9515691A1_I_>

loam soil and treated at the following growth stages:

Broad-leafed weeds	
Ipomoea purpurea	1 leaf
Sida spinosa	1-2 leaf
Xanthium strumarium	2+1 leaf
Grass Weeds	
Digitaria sanguinalis	3 leaf
Setaria viridis	3 leaf

Treated plants were maintained on moist capillary matting under lights in a glasshouse. They received one overhead watering 24 hours after treatment and thereafter were sub-irrigated three times daily. Treatment effects were assessed visually 14 days after treatment. The percentage damage compared to untreated controls was recorded for each species.

The tables below show the observed percentage control of the weed species by each combination, with the figure in brackets representing the predicted value using the Limpel formula.

RESULTS

Example D1

Post-emergence treatment of Ipomoea purpurea with various mixtures of Compound F and metribuzin

	Metribuzin			
Dose g/ha	0	32	63	125
0	-	0	0	20
8	10	40 (10)	60 (10)	60 (28)
16	20	50 (20)	50 (20)	70 (36)
32	40	60 (40)	65 (40)	70 (52)
63	40	60 (40)	70 (40)	75 (52)

Cpd F

BNSDOCID: <WO___9515691A1_I_>

Example D2

Post-emergence treatment of Sida spinosa with various mixtures of Compound F and metribuzin

		Metribuzin		
	Dose g/ha	0	16	32
	0	-	20	30
Cpd F	8	0	30 (20)	70 (30)
	16	40	70 (52)	85 (58)

Example D3

Post-emergence treatment of Xanthium strumarium with various mixtures of Compound F and metribuzin

		Metribuzin				
	Dose g/ha	0	16	32	63	125
Cpd F	0	-	10	20	40	60
	8	10	30 (19)	60 (28)	65 (46)	100 (64)

Example D4

Post-emergence treatment of Digitaria sanguinalis with various mixtures of Compound F and metribuzin

		Metribuzin		
	Dose g/ha	0	16	32
	0	-	0	10
Cpd F	8	10	20 (10)	60 (19)
	16	30	60 (30)	70 (37)

Example D5

Post-emergence treatment of Setaria viridis with various mixtures of Compound F and metribuzin

		Metribuzin		
	Dose g/ha	0	16	32
	0	-	0	20
	8	0	40	60 (20)
Cpd F	16	30	60 (30)	70 (44)
	32	30	70 (30)	80 (44)
	63	45	70 (45)	80 (56)

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According to a further feature of the present invention there are provided herbicidal compositions comprising

(a) a 4-benzoylisoxazole derivative of formula I as defined above; and

(b) a triazine herbicide;

in association with, and preferably homogeneously dispersed in a herbicidally acceptable diluent or carrier and/or surface active agent.

The term "herbicidal composition" is used in a broad sense, to include not only compositions which are ready for use as herbicides but also concentrates which must be diluted before use. Preferably, the compositions contain from 0.05 to 90% by weight of 4-benzoylisoxazole and triazine herbicide.

Unless otherwise stated, the percentages and ratios appearing in this specification are by weight.

Generally a composition in which the ratio of (a):(b) is from 2:1 to 1:1000 wt/wt is used, proportions of of (a) : (b) from 1:3.3 to 1:60 wt/wt being particularly preferred.

The herbicidal composition may contain solid and liquid carriers and surface-active agents (e.g. wetters, dispersants or emulsifiers alone or in combination). Surface-active agents that may be present in the herbicidal compositions of the present invention may be of the ionic or non-ionic types, for example sulphoricinoleates, quaternary ammonium derivatives, products based on condensates of ethylene oxide with nonyl- or octyl-phenols, or carboxylic acid esters of anhydrosorbitols which have been rendered soluble by etherification of the free hydroxy groups by condensation with ethylene oxide, alkali and alkaline earth metal salts of sulphuric acid esters and sulphonic acids such as dinonyl- and dioctyl-sodium sulphono-succinates and alkali and alkaline earth metal salts of high molecular weight sulphonic acid derivatives such as sodium and calcium lignosulphonates. Examples of suitable solid diluents or carriers are aluminium silicate, talc, calcined magnesia, kieselguhr, tricalcium phosphate, powdered cork, absorbent carbon black and clays such as kaolin and bentonite. Examples of suitable liquid diluents include water, acetophenone, cyclohexanone, isophorone, toluene, xylene, and mineral, animal,

BNSDOCID: <WO__9515691A1_I_>

and vegetable oils (these diluents may be used alone or in combination).

Herbicidal compositions according to the present invention may also contain, if desired, conventional adjuvants such as adhesives, protective colloids, thickeners, penetrating agents, stabilisers, sequestering agents, anti-caking agents, colouring agents and corrosion inhibitors. These adjuvants may also serve as carriers or diluents.

The wettable powders (or powders for spraying) usually contain from 20 to 95% of 4-benzoylisoxazole and triazine herbicide, and they usually contain, in addition to the solid vehicle, from 0 to 5% of a wetting agent, from 3 to 10% of a dispersant agent and if necessary, from 0 to 10% of one or more stabilisers and/or other additives such as penetrating agents, adhesives or anti-caking agents and colourings.

The aqueous suspension concentrates, which are applicable by spraying, are prepared in such a way as to obtain a stable fluid product (by fine grinding) which does not settle out and they usually contain from 10 to 75% of 4-benzoylisoxazole and triazine herbicide, from 0.5 to 15% of surface acting agents, from 0.1 to 10% of thixotropic agents, from 0 to 10% of suitable additives such as antifoams, corrosion inhibitors, stabilisers, and water or an organic liquid in which the active substance is sparingly soluble or insoluble. Some organic solid substances or inorganic salts can be dissolved in order to assist in preventing sedimentation or as antifreeze for the water.

Preferred herbicidal compositions according to the present invention are wettable powders and water-dispersible granules.

Herbicidal compositions according to the present invention may also comprise a 4-benzoylisozaxole and a triazine herbicide in association with, and preferably homogeneously dispersed in, one or more other pesticidally active compounds and, if desired one or more compatible pesticidally acceptable diluents and carriers. Preferred herbicidal compositions according to the present invention are those which comprise a 4-benzoylisozaxole and a triazine herbicide in association with other herbicides.

The compositions of the invention may be made up as an

article of manufacture comprising a 4-benzoylisoxazole and a triazine herbicide and optionally other pesticidally active compounds as hereinbefore described, and as is preferred, a herbicidal composition as hereinbefore described and preferably a herbicidal concentrate which must be diluted before use, comprising the 4-benzoylisozaxole and triazine herbicide within a container for the aforesaid 4-benzoylisozaxole and triazine or a said herbicidal composition and instructions physically associated with the aforesaid container, setting out the manner in which the aforesaid 4-benzoylisozaxole and triazine or herbicidal composition contained therein, is to be used to control the growth of weeds. The containers will normally be of the types conventionally used for the storage of chemical substances and concentrated herbicidal compositions, which are solids or liquids at normal ambient temperatures, for example cans and drums of plastics materials or metal (which may be internally-lacquered), bottles of glass and plastics materials; and when the contents of the container is a solid, for example a granular herbicidal composition, boxes, for example of cardboard, plastics material, metal or sacks. The containers will normally be of sufficient capacity, to contain amounts of the active ingredients or herbicidal compositions sufficient to treat at least one hectare of ground, to control the growth of weeds therein but will not exceed a size which is convenient for conventional methods of handling. Instructions will be physically associated with the container, for example by being printed directly thereon or on a label or tag affixed thereto. The directions will normally indicate that the contents of the container, after dilution if necessary, are to be applied to control the growth of weeds at rates of application from 5 to 500g of 4-benzoylisozaxole and from 250g to 5000g of a triazine herbicide per hectare in the manner and for the purpose hereinbefore described.

According to a further feature of the present invention, there is provided a product comprising (a) 4-benzoylisozaxole of formula I above and (b) a triazine herbicide, as a combined preparation for simultaneous, separate or sequential use in controlling the growth of weeds at a locus.

While the invention has been described in terms of various

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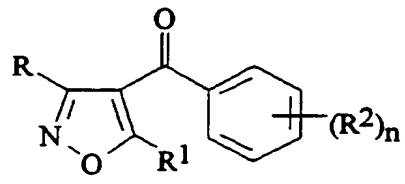
preferred embodiments, the skilled artisan will appreciate that various modifications, substitutions, omissions, and changes may be made without departing from the spirit thereof. Accordingly, it is intended that the scope of the present invention be limited solely by the scope of the following claims, including equivalents thereof.

CLAIMS

1. A method for controlling the growth of weeds at a locus which comprises applying to the locus:

(a) a 4-benzoylisoxazole derivative of formula I:



(I)

wherein

R is hydrogen or $-CO_2R^3$;

R^1 is cyclopropyl;

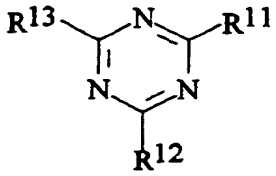
R^2 is selected from halogen, $-S(O)_pMe$ and C_{1-6} alkyl or haloalkyl;

n is two or three; p is zero, one or two; and

R^3 is C_{1-4} alkyl; and

(b) a triazine herbicide.

2. A method according to claim 1 wherein the triazine herbicide is a compound of formula II:



(II)

wherein R^{11} represents chlorine or straight- or branched chain alkylthio or alkoxy having from one to six carbon atoms; R^{12} represents azido, monoalkylamino, dialkylamino or cycloalkylamino, in which the alkyl or cycloalkyl moieties may be optionally substituted by one or more substituents selected from cyano and alkoxy; and R^{13} represents straight-or branched- chain N-alkylamino having from one to six carbon atoms;

or of formula (III)

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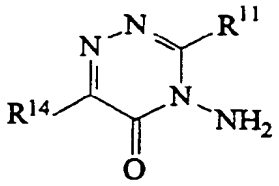

(III)

wherein R^{11} is as defined above and R^{14} represents straight- or branched chain alkyl having from one to six carbon atoms.

3. A method according to claim 2 wherein in formula II, R^{12} represents azido, straight- or branched- chain N-alkylamino having from one to four carbon atoms (wherein the alkyl moiety is optionally substituted by cyano or methoxy).

4. A method according to claim 1 or 2 wherein the triazine herbicide is selected from:

simazine, which is 6-chloro-N^2,N^4-diethyl-1,3,5-triazine-2,4-diamine;

cyanazine, which is 2-(4-chloro-6-ethylamino-1,3,5-triazin-2-ylamino)-2-methylpropionitrile;

or atrazine, which is 6-chloro-N^2-ethyl-N^4-isopropyl-1,3,5-triazine-2,4-diamine.

5. A nethod according to claim 4 wherein the triazine herbicide is cyanazine or atrazine.

6. A method according to claim 1 or 2 wherein the triazine herbicide is metribuzin, which is 4-amino-6-*tert*-butyl-3-methylthio-1,2,4-triazin-5(4H)-one.

7. A method according to any one of the preceding claims wherein in formula I, one of the groups R^2 is $-S(O)_pMe$ and p is as defined in claim 1.

8. A method according to any one of the preceding claims wherein in formula I n is three and the groups $(R^2)_n$ occupy the 2, 3 and 4-positions of the benzoyl ring; or n is two and the

BNSDOCID: <WO___9515691A1_I_>

groups $(R^2)_n$ occupy the 2 and 4- positions of the benzoyl ring.

9. A method according to any one of the preceding claims wherein in formula I $(R^2)_n$ represents 2-SO_2Me-4-CF_3, 2-CF_3-4-SO_2Me, 2-Cl-4-SO_2Me, 2-SO_2Me-4-Br, 2-SO_2Me-4-Cl or 2-SMe-3,4-dichloro.

10. A method according to any one of the preceding claims in which the compound of formula I is 5-cyclopropyl-4-(2-methylsulphonyl-4-trifluoromethyl)benzoylisoxazole.

11. A method according to any one of claims 1 to 9 in which the compound of formula I is ethyl 3-[5-cyclopropyl-4-(3,4-dichloro-2-methylsulphenyl)benzoylisoxazole]carboxylate.

12. A method according to any one of the preceding claims in which the application rate of 4-benzoylisoxazole is from 5g to 500g per hectare and the application rate of triazine herbicide is from 250g to 5000g per hectare.

13. A method according to any one of the preceding claims in which the application rate of 4-benzoylisoxazole is from 25g to 150g per hectare and the application rate of triazine herbicide is from 500g to 1500g per hectare.

14. A method according to any one of the preceding claims for the control of grass weeds in maize.

15. A method according to any one of the preceding claims wherein the compounds are applied pre-emergence of the weeds.

16. A method according to claim 6 wherein the compounds are applied post-emergence of the weeds.

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17. A herbicidal composition comprising:

(a) a 4-benzoylisoxazole derivative of formula I as defined in claim 1; and

(b) a triazine herbicide;

in association with a herbicidally acceptable diluent or carrier and/or surface active agent.

18. A herbicidal composition according to claim 17 wherein the ratio of (a):(b) is from 2:1 to 1:1000 wt/wt.

19. A herbicidal composition according to claim 17 or 18 in which the ratio of (a):(b) is from 1:3.3 to 1:60 wt/wt.

20. A product comprising (a) 4-benzoylisozaxole of formula I as defined in claim 1 and (b) a triazine herbicide, as a combined preparation for simultaneous, separate or sequential use in controlling the growth of weeds at a locus.

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FIG I/VIII

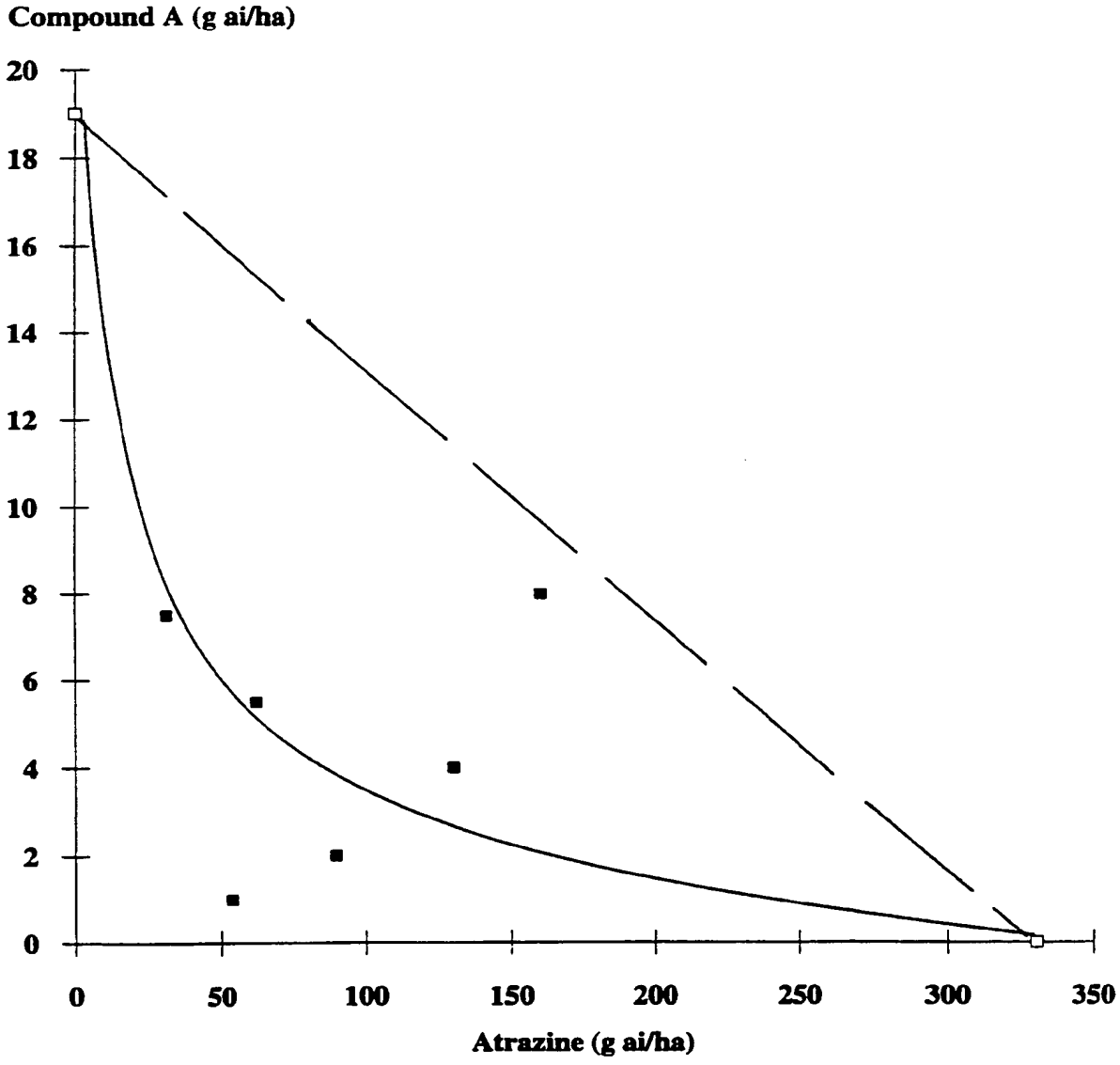

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FIG II/VIII

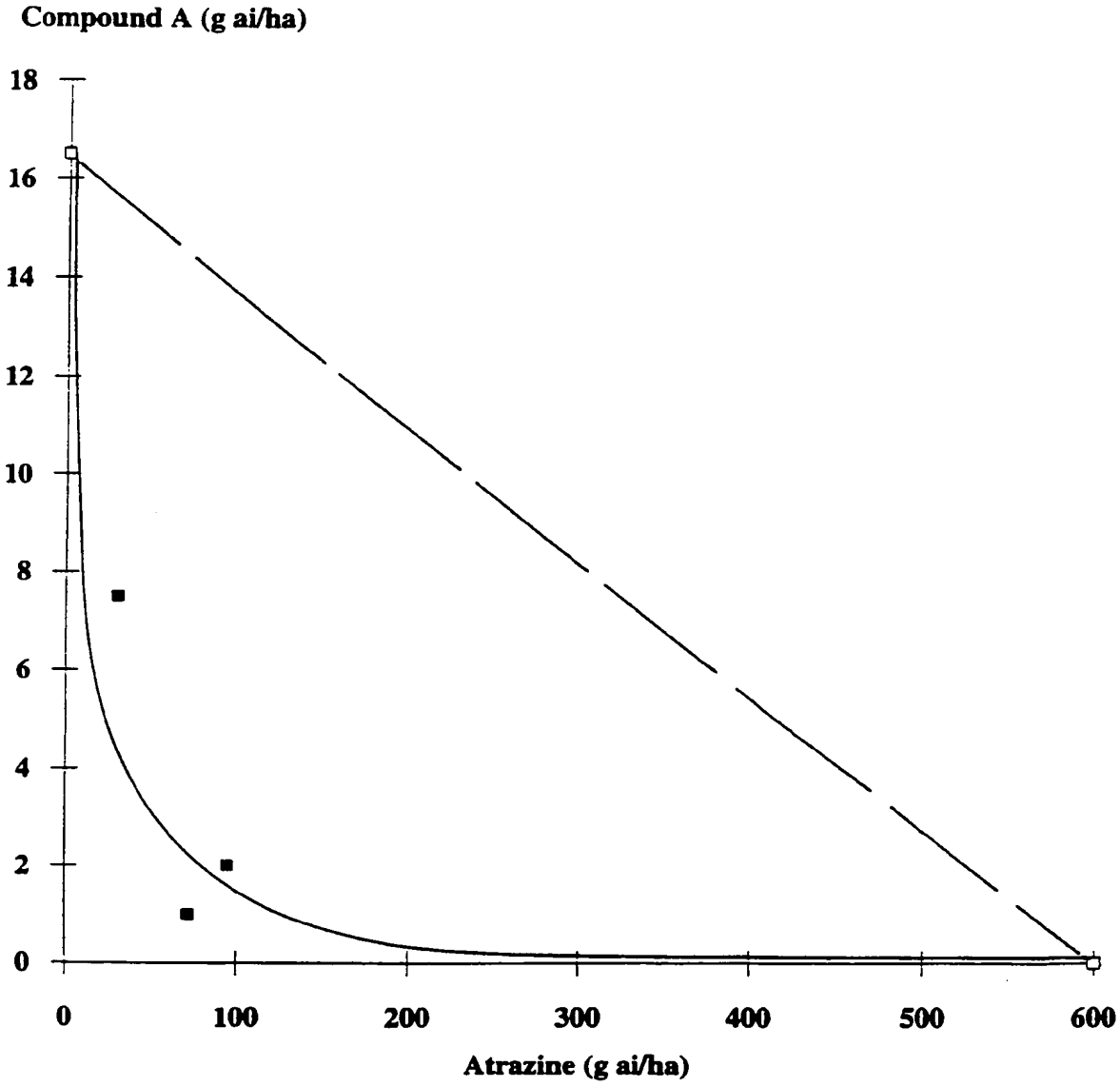
Compound A (g ai/ha)
18
16
14
12
10
8
6
4
2
0
0
100
200
300
400
500
600
Atrazine (g ai/ha)

FIG III/VIII

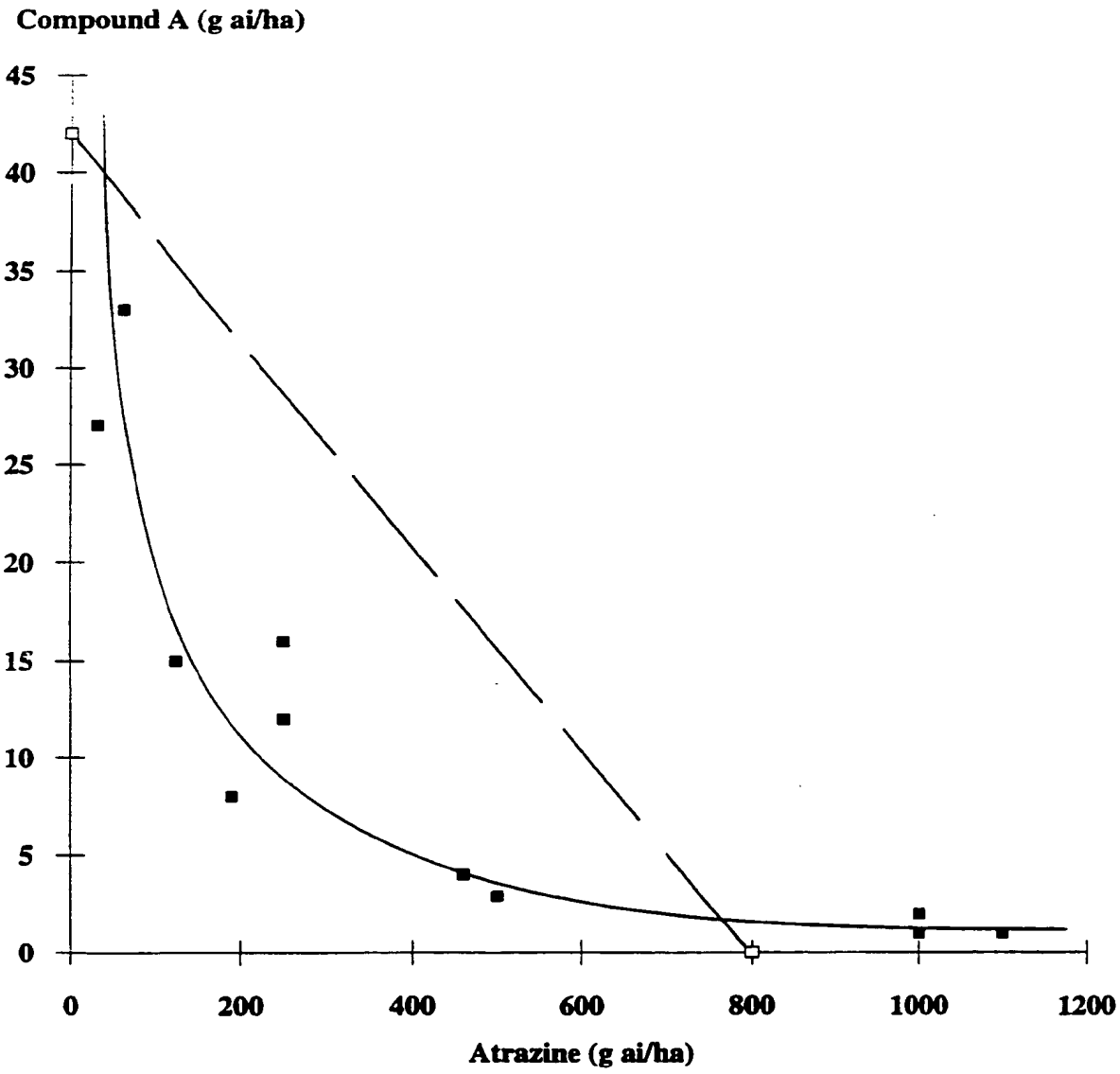

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FIG IV/VIII

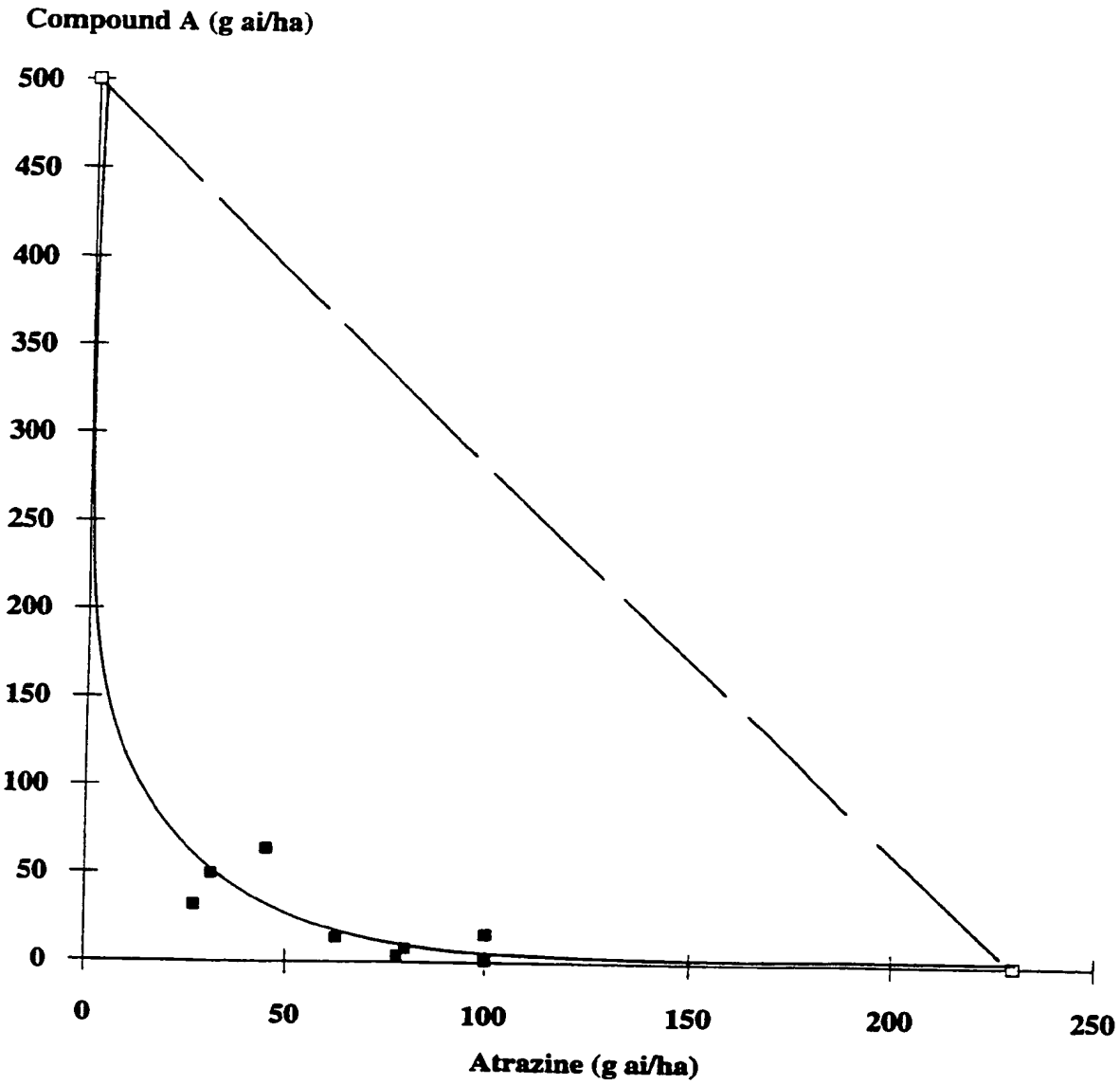

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FIG V/VIII

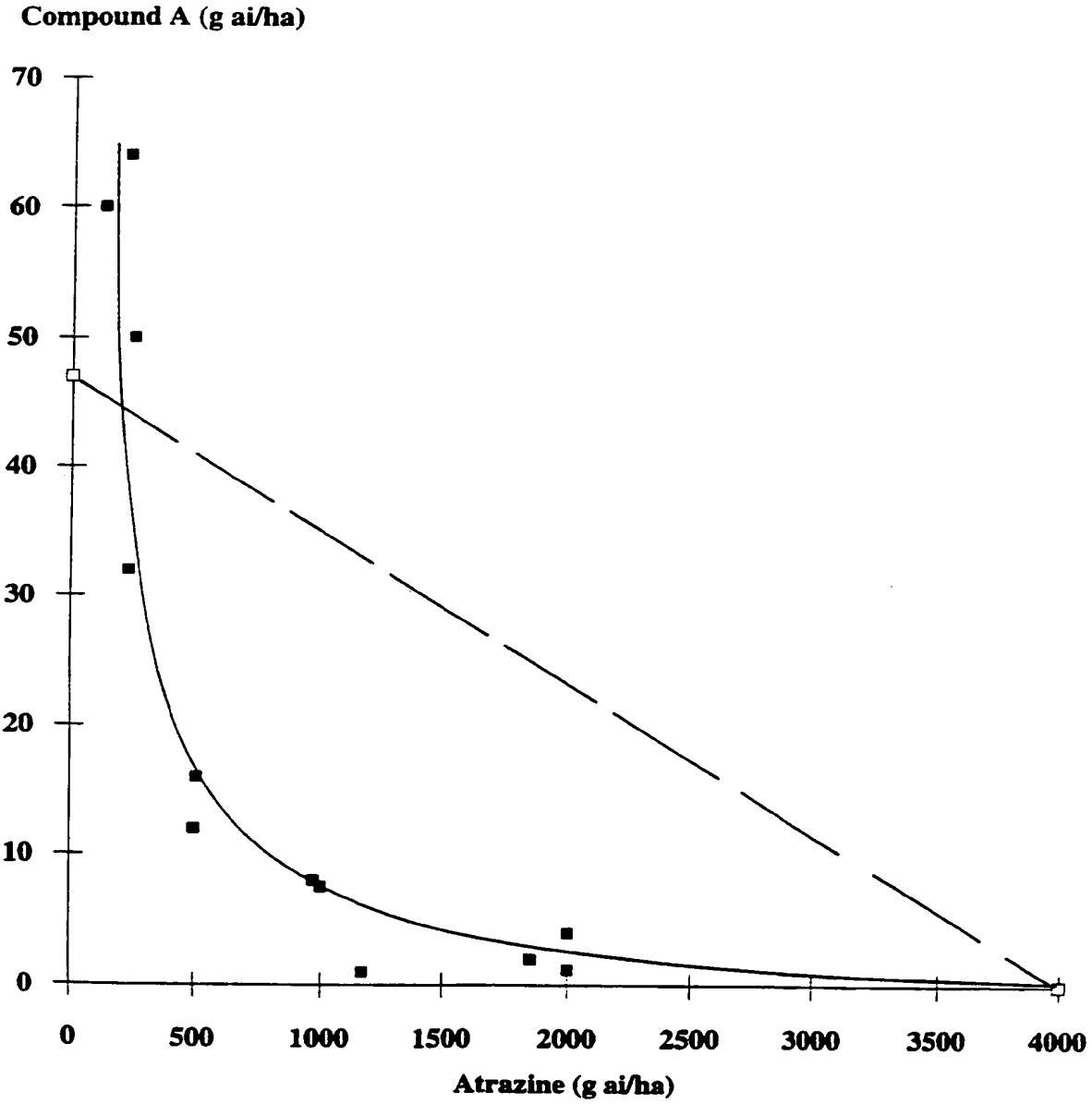

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FIG VI/VIII

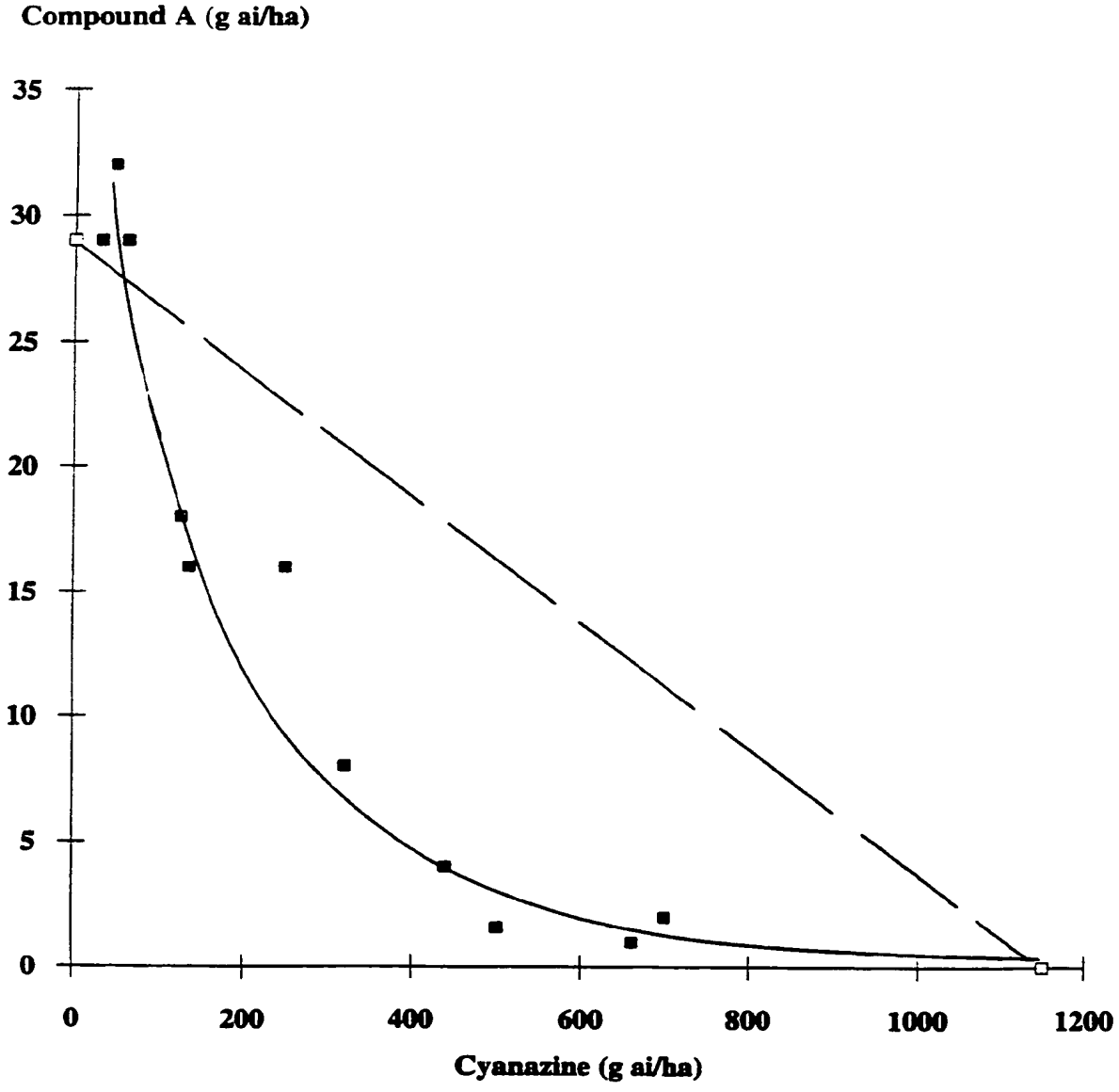

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FIG VII/VIII

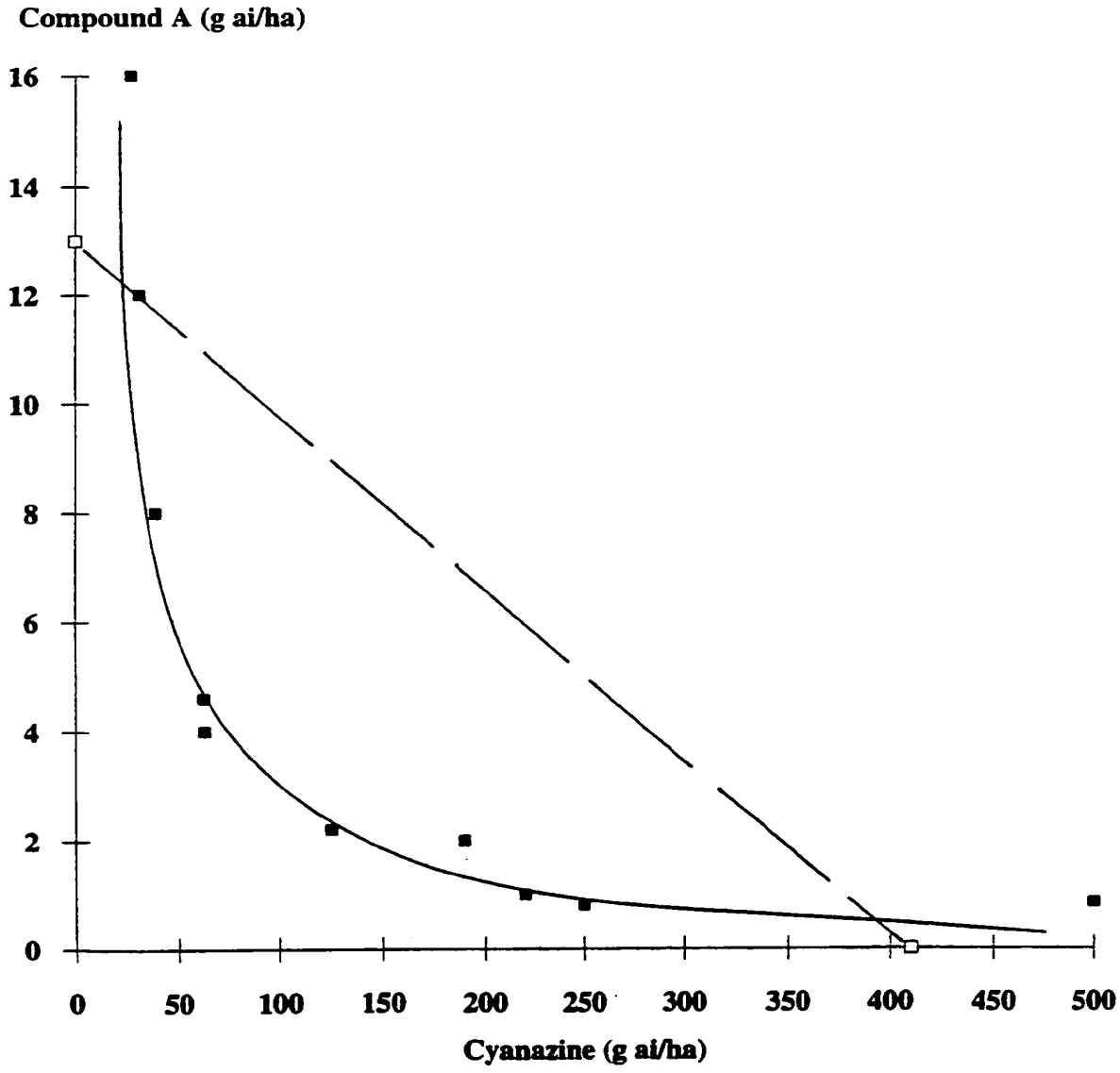

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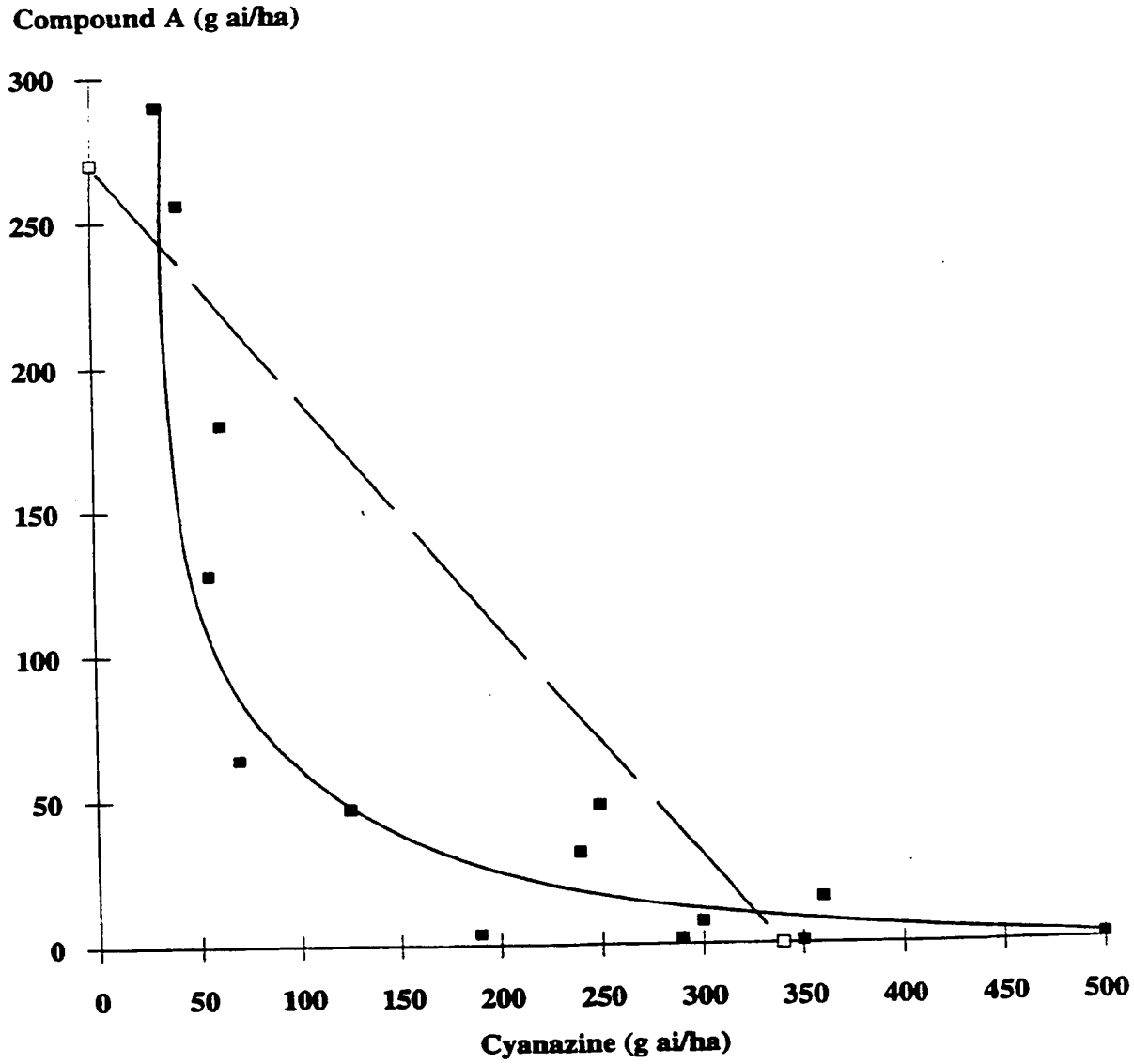
FIG VIII/VIII



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INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/EP 94/04052

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A01N43/80 //(A01N43/80,43.707,43:70)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 527 036 (RHONE POULENC AGRICULTURE) 10 February 1993 cited in the application see page 2, line 1 - line 22 see page 10, line 24 - line 38 ---	1-5, 7-10, 12-20
X	EP,A,0 418 175 (RHONE POULENC AGRICULTURE) 20 March 1991 cited in the application see page 4, line 54 - line 55 see page 5, line 27 - line 28 see page 34, line 51 - line 28 see page 5, line 15 --- -/--	1-9, 12-20

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 April 1995	18.04.95

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Lamers, W

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PCT/EP 94/04052

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 560 482 (RHONE POULENC AGRICULTURE) 15 September 1993 cited in the application see page 3, line 27 see page 3, line 34 see page 20, line 57 - page 21, line 11	1-9, 11-20
A	CHEMICAL ABSTRACTS, vol. 121, no. 9, 29 August 1994 Columbus, Ohio, US; abstract no. 101871, R.POLLAK ET AL. 'The development of isoxaben for fruit and ornamental crops' see abstract & BRIGHTON CROP PROT. CONF.--WEEDS, vol. 3, 1993 pages 1067-1072,	1-20
A	DATABASE WPI Section Ch, Week 8402 7 March 1984 Derwent Publications Ltd., London, GB; Class C, AN 84-006056 [02] & CA,A,1 158 058 (ELI LILLY) , 6 December 1983 see abstract	20

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INTERNATIONAL SEARCH REPORT

information on patent family members

Inte ɔnal Application No
PCT/EP 94/04052

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A-0527036	10-02-93	AU-B-	655648	05-01-95
		AU-A-	2073092	11-02-93
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		CN-A-	1069268	24-02-93
		JP-A-	5202008	10-08-93
		NZ-A-	243817	24-02-95
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		US-A-	5334753	02-08-94

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FIG I/VIII

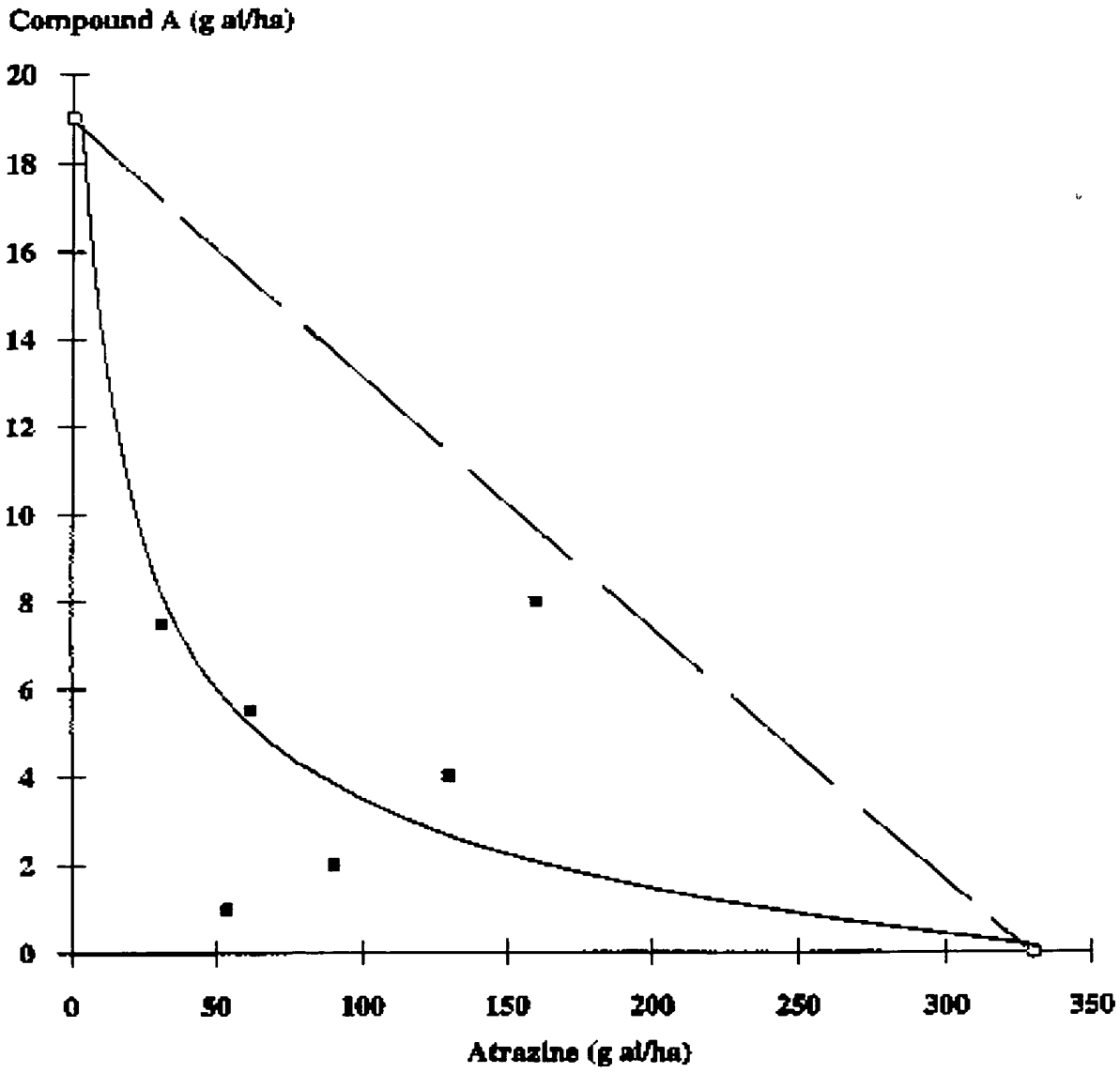

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FIG II/VIII

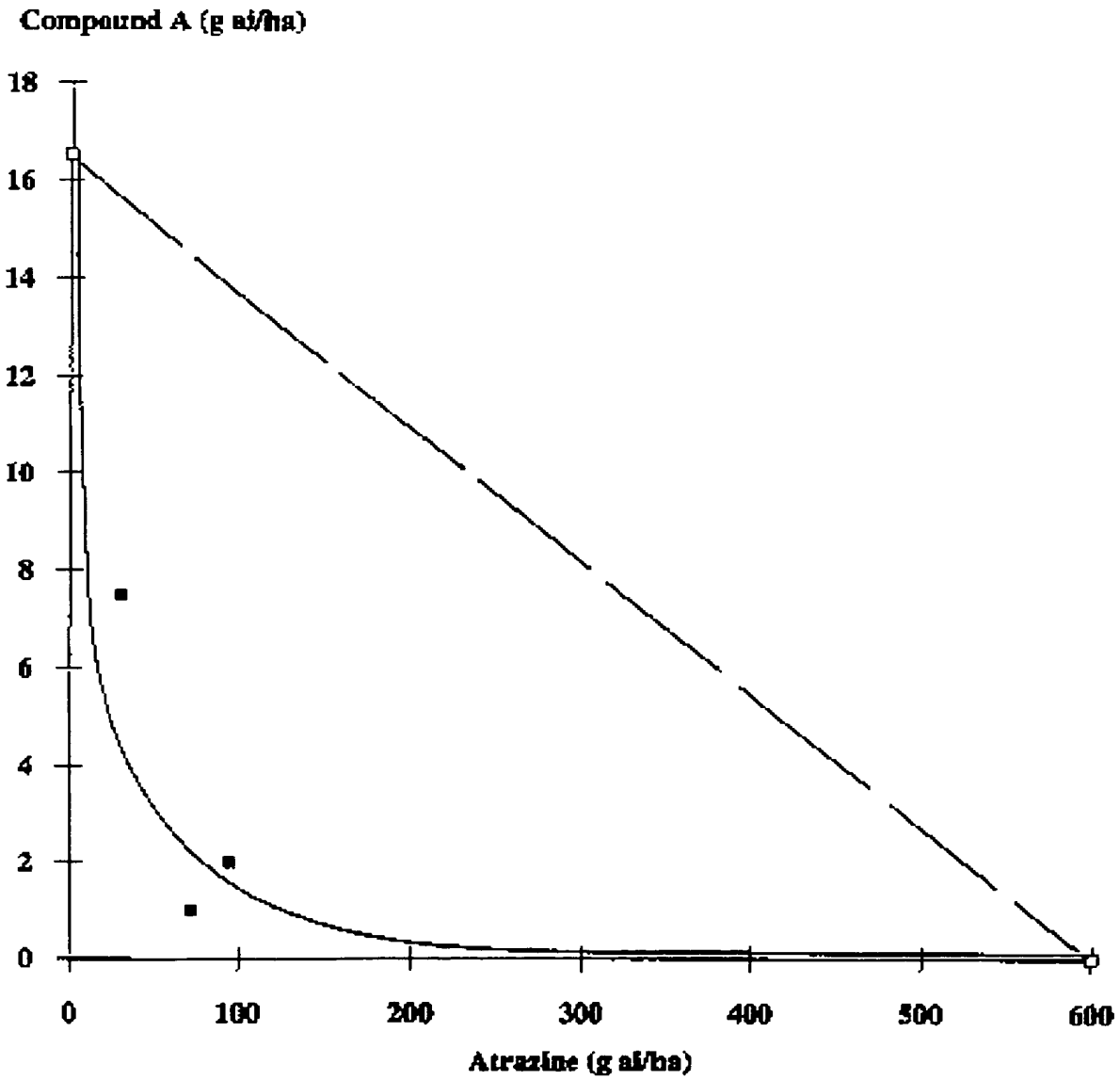

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FIG III/VIII

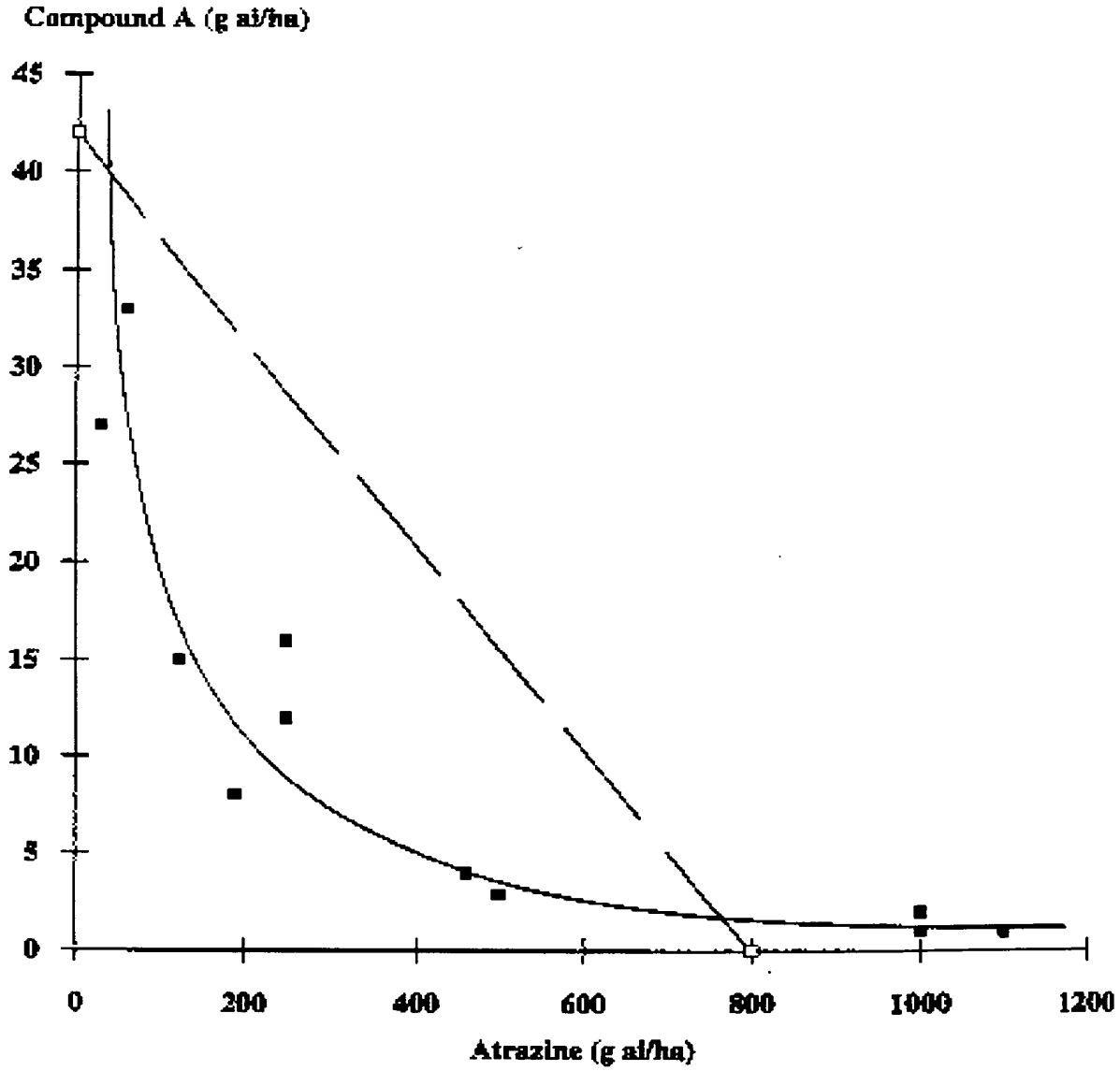

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FIG IV/VIII

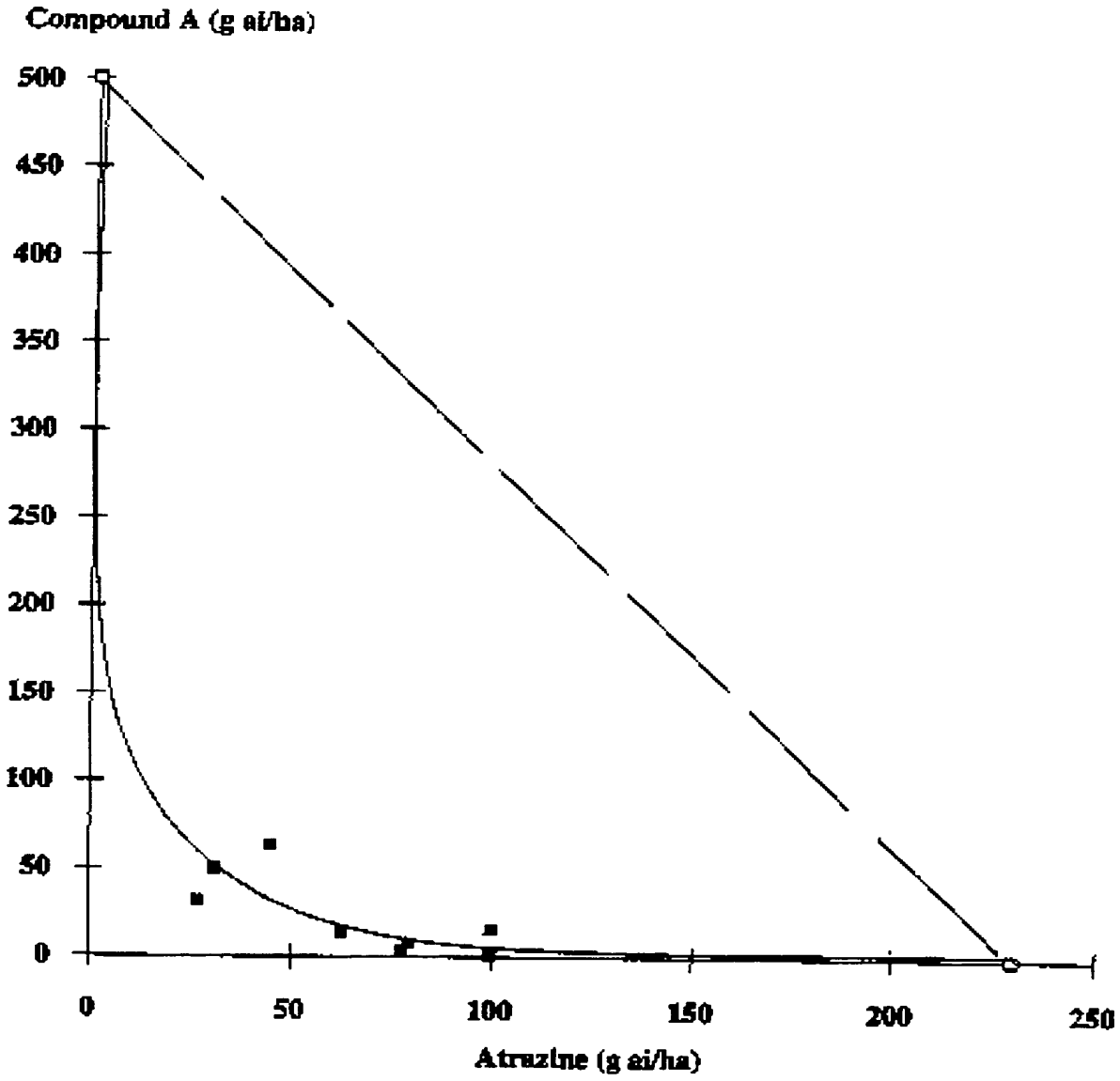

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FIG V/VIII

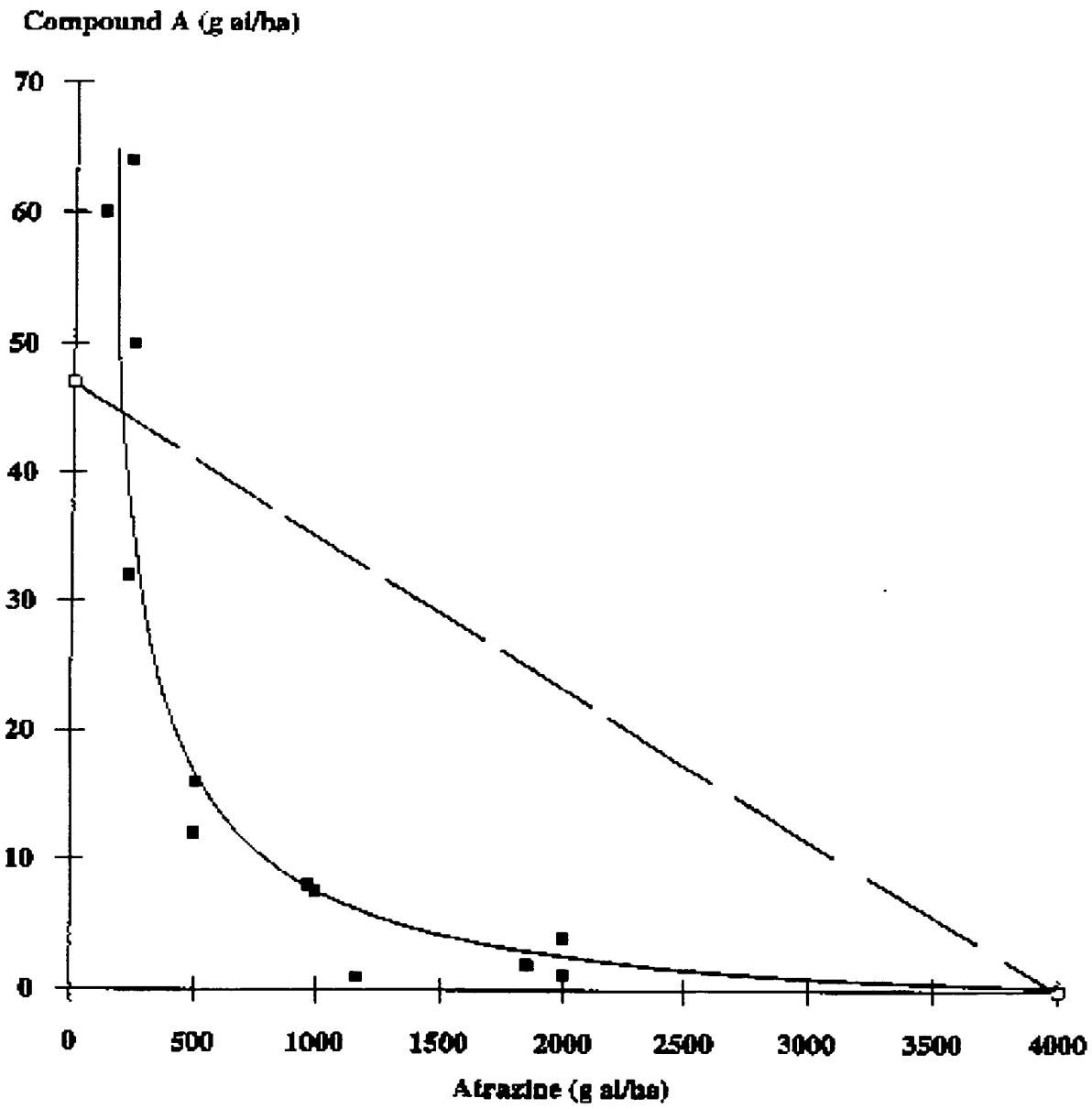

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FIG VI/VIII

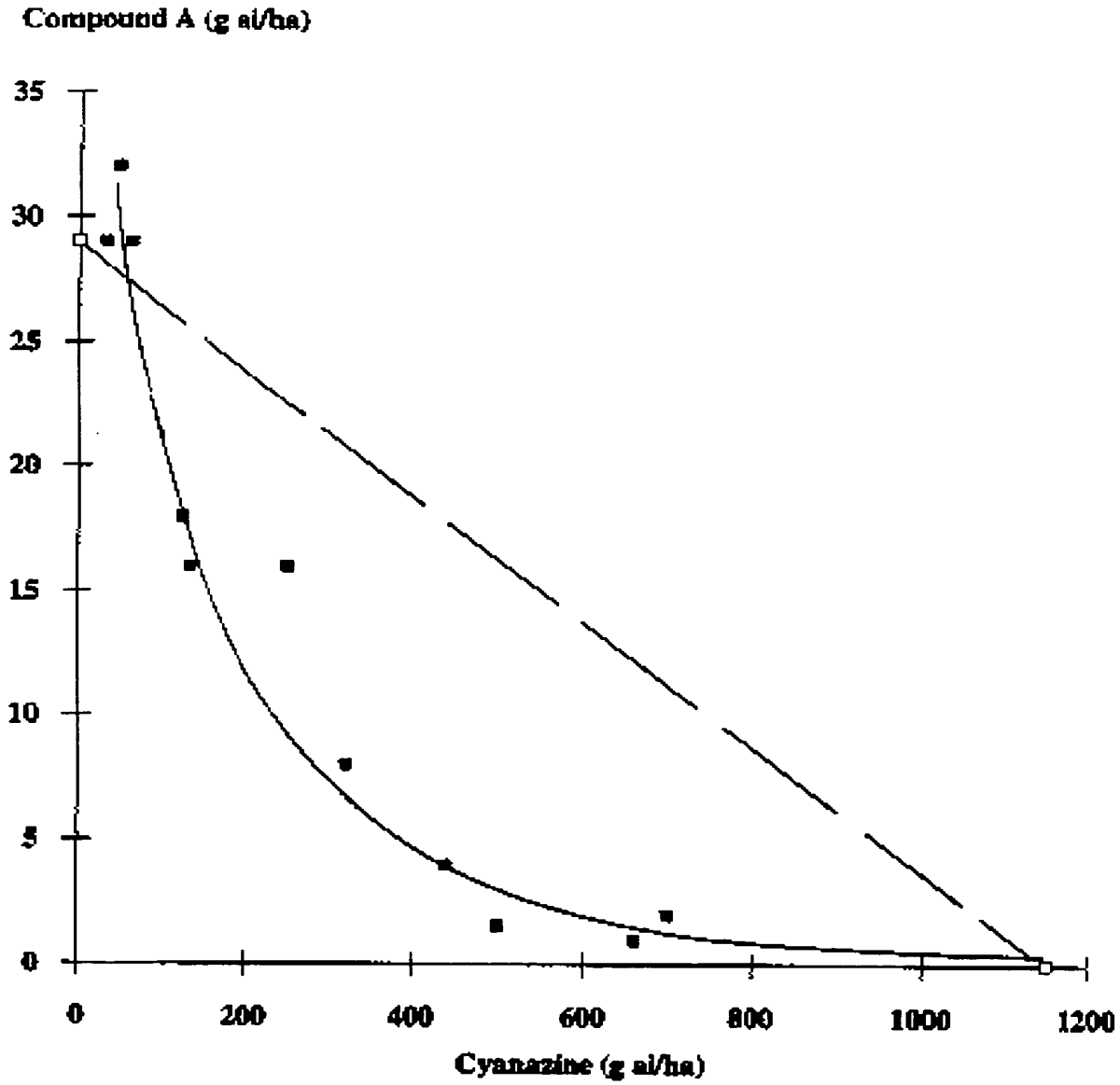

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FIG VII/VIII

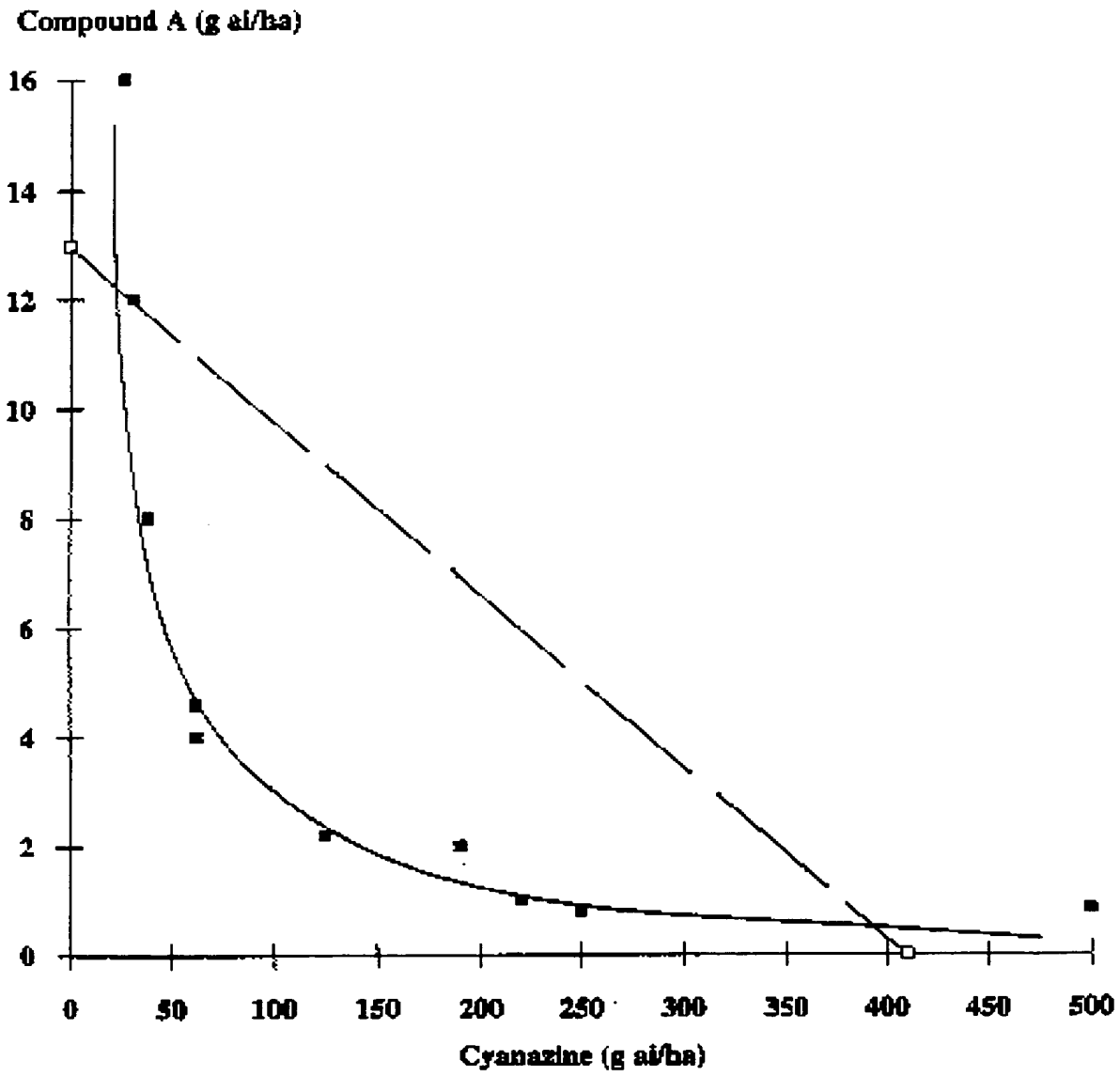

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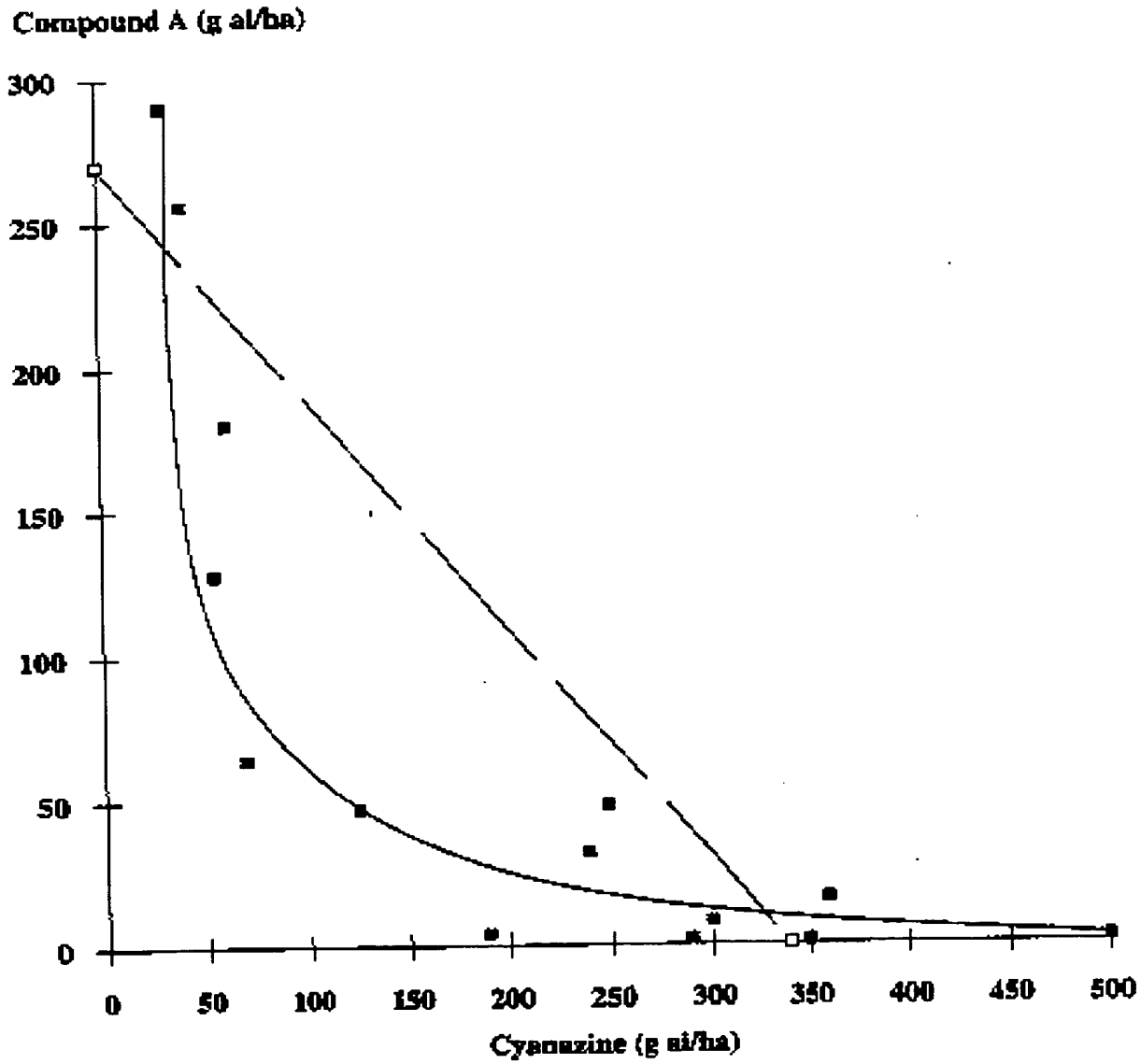
FIG VIII/VIII



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